

Aspirin can be prepared in the laboratory by the reaction of an acyl chloride with salicylic acid.

(c) Draw the full structural formula of the acyl chloride you would use in this reaction.

[2]

A solid sample of aspirin prepared using this method was found to be impure.

(d) (i) Name the technique you would use to purify the sample.

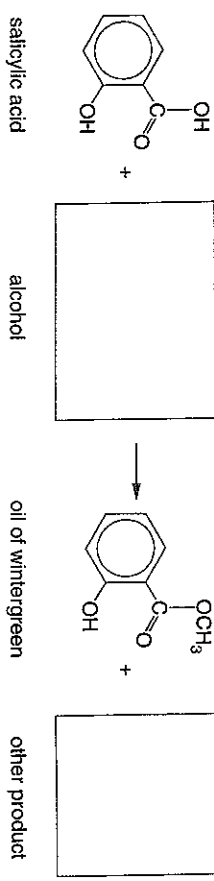
[1]

(ii) How would you determine whether the sample is pure?

[2]

Oil of wintergreen is also a painkiller and is sold as a cream to be applied directly to the skin. It can be made by heating salicylic acid under reflux with an alcohol and a suitable catalyst.

(e) (i) Complete the equation below to show the structural formula of the alcohol you would use and the formula of the other product formed.



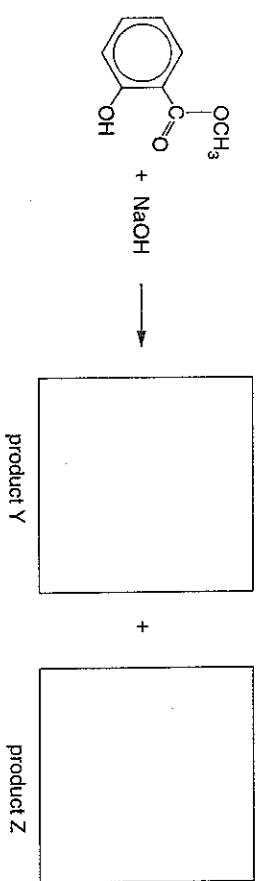
[2]

(ii) Name a suitable catalyst for this reaction.

[1]

Oil of wintergreen can be hydrolysed to give two products.

(f) Complete the equation below to show the structure of the products formed when oil of wintergreen is hydrolysed with aqueous sodium hydroxide.

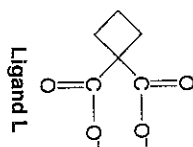


[3]

[Total : 15]

Cisplatin has been found to have toxic side effects, so alternative compounds are being investigated. One of these is called carboplatin.

Carboplatin contains the following ligand, L.



Carboplatin has a similar structure to cisplatin, but with ligand L replacing the two chloride ligands.

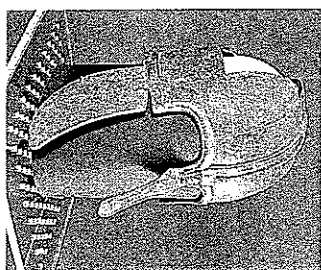
(e) Draw the structure of carboplatin below showing how ligand L bonds to the platinum ion.

(f) What name is given to a ligand, such as ligand L, that has two points of attachment to the metal ion?

..... [1]

[Total : 20]

3 When archaeologists were excavating a Viking settlement in Coppergate, York, they discovered an almost perfectly preserved Anglian helmet.

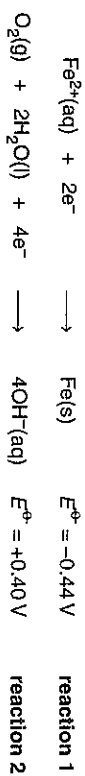


The ground in which the helmet was buried was completely waterlogged which meant that the parts of the helmet made from iron had corroded very slowly. When the helmet was excavated it began to corrode very quickly.

(a) Suggest why corrosion of the helmet underground had taken place very slowly.

..... [1]

(b) The first stage of rusting is an electrochemical process involving the following half-equations.



(i) Write an overall equation for the first stage of the rusting process.

..... [2]

(ii) Calculate E_{cell} for the overall reaction in (b)(i).

..... [1]

(iii) Suggest a formula for rust and explain how it is formed from the product of the reaction in (b)(i).

..... [2]

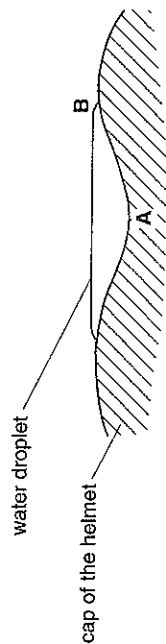
The helmet was found to have a large dent in the cap. After excavation, rust was particularly evident around the dent.

(c) (i) Give the half-equations for the reactions occurring at A and B on the diagram below.

Half-equation at A

Half-equation at B [3]

(ii) On the diagram below label the direction of the electron flow in the surface of the helmet.



[1]

Rusting is also a problem for oil rigs, as their steel supports are surrounded by sea water. Sea water contains dissolved sodium chloride. The presence of dissolved sodium chloride speeds up the rusting process.

(d) Suggest why the presence of dissolved sodium chloride speeds up the rusting process.

..... [1]

(e) The steel supports of oil rigs are protected from rusting by bolting blocks of another metal onto them. Using the information below name a metal that could be used to protect the steel supports from rusting. Explain your choice and describe how the rusting process is prevented.

$Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$	$E^\ominus = -2.36 V$
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	$E^\ominus = -0.76 V$
$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$	$E^\ominus = -0.44 V$
$Sn^{2+}(aq) + 2e^- \rightarrow Sn(s)$	$E^\ominus = -0.14 V$

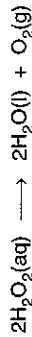
..... [4]

[Total : 15]

[Turn over

4 Permanent hair dyes contain hydrogen peroxide, which is used to bleach hair.

Hydrogen peroxide decomposes very slowly on storage. The equation for its decomposition is shown below.



One method of following this is by titration with acidified potassium manganate(VII).

The reaction can be speeded up by the presence of a catalyst.

A group of students investigated the effect of the catalyst on the rate of decomposition of a solution of hydrogen peroxide. They removed 10 cm³ portions at timed intervals and titrated each portion with 0.1 mol dm⁻³ acidified potassium manganate(VII) solution.

5 moles of H₂O₂ react with 2 moles of KMnO₄

The following data were obtained.

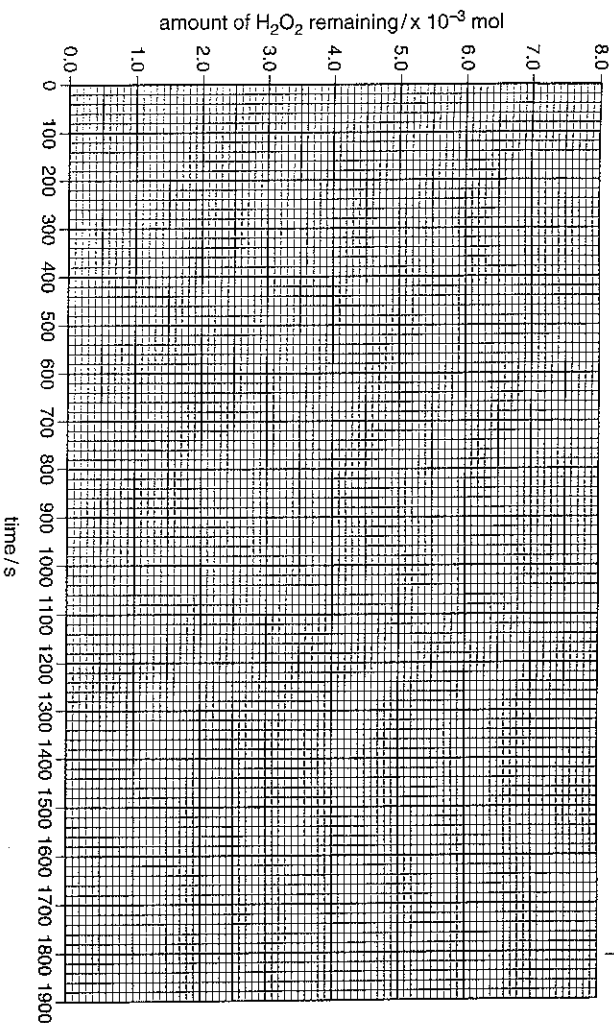
time /seconds	volume of 0.1 mol dm ⁻³ KMnO ₄ (aq) / cm ³	amount of H ₂ O ₂ remaining in 10 cm ³ of solution / x 10 ⁻³ mol
0	30.0	7.50
300	23.4	5.90
600	18.3	4.60
900	14.2	3.60
1200	11.1	2.80
1500	8.70	2.18
1800	6.80	

(a) Complete the table above to show the amount of hydrogen peroxide remaining in 10 cm³ of the reaction mixture after 1800 seconds.

Show your working below.

[2]

- (b) (i) Plot a graph of the amount of hydrogen peroxide remaining in 10 cm³ of reaction mixture against time on the grid below.



- (ii) How does your graph confirm that the reaction is first order with respect to the concentration of hydrogen peroxide? Show clearly how you arrived at your answer.

[3]

In a separate set of experiments, the students found that the order of reaction with respect to the catalyst was zero.

[3]

- (c) (i) Write the rate equation for the reaction.

[2]

- (ii) The rate is measured in mol dm⁻³ s⁻¹. Work out the units of the rate constant, showing your working.

Units of rate constant are [2]

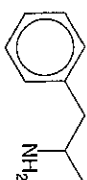
[Total : 12]

[Turn over

- 5 Amphetamines are synthetic chemicals which can act as stimulants.

The first amphetamine to be marketed was called *Benzedrine*, which was used in World War II to enable soldiers to stay awake for long periods of time.

The structure of *Benzedrine* is shown below.

*Benzedrine*

- (a) Draw an asterisk(*) next to the chiral carbon atom on the structure of *Benzedrine*. [1]
A more potent form of the drug is its mirror image *Dexedrine*.

- (b) Draw the 3-dimensional structures of *Benzedrine* and its mirror image *Dexedrine*. (You do not need to label which is which).

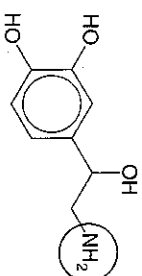
mirror



[2]

The structures of amphetamines resemble that of noradrenaline. Noradrenaline is a molecule made in our bodies that affects blood pressure.

The structure of noradrenaline is shown below.

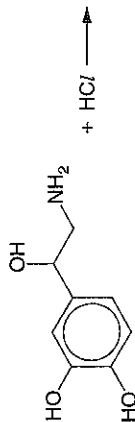


noradrenaline

- (c) (i) Name the functional group circled on noradrenaline.

[1]

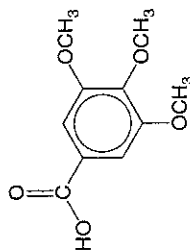
- (ii) Complete the equation below to show the product formed from the reaction of noradrenaline with dilute hydrochloric acid.



[2]

People who suffer from high blood pressure can be given a drug called reserpine which lowers the amount of noradrenaline in the nerve endings. This lowers blood pressure.

When reserpine is hydrolysed one of the products formed is Compound R.



Compound R

The proton nmr spectrum of Compound R contains three signals.

- (d) Use the data sheet which accompanies this paper to complete the table below.

chemical shift in the region	type of proton	relative number of protons
3.7		
11.0		1
7.5		

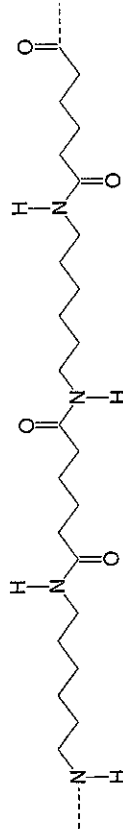
[4]

[Total : 10]

- 6 Some of the properties of nylon were discovered accidentally by chemists working on polyesters. They decided to see how far a strand of polyester could be stretched around the laboratory. They realised that as they stretched the strands they were orienting the molecules and observed that the strands took on a silky appearance.

They found that a similar thing happened with nylon. The nylon had a greater tensile strength and a higher melting temperature than the polyesters and so was better for producing fibres.

Part of a polymer chain of nylon-6,6 is shown below.



- (a) The process of pulling the polymer into strands is called cold drawing. Explain why cold drawing increases the tensile strength of a polymer.

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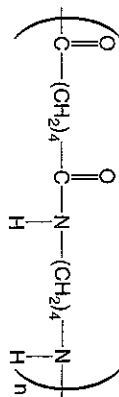
[3]

Nylon-6,6 and nylon-6 have dominated the polyamide market for many years. Another competitor has now been developed, a polyamide sold under the trade name *Stanyl*. *Stanyl* is made from two monomers, hexanedioic acid and 1,4-diaminobutane.

- (b) Draw the full structural formula of 1,4-diaminobutane in the space below.

[2]

The repeating unit of Stanyl is shown below.



Initially Stanyl was rejected because its molecular mass was considered to be too low. However, Stanyl has recently been produced with a molecular mass in the region of 30 000. Stanyl has a greater tensile strength and melts at a higher temperature than nylon-6,6.

- (c) (i) Stanyl melts at a higher temperature than nylon-6,6. Explain why this is so. (You may assume that the polymer chains have a similar M_n .)

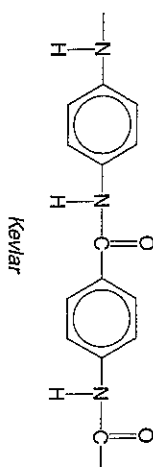
.....

 [4]

- (ii) How many repeating units would you expect to be present in a polymer chain of Stanyl of M_n 32 000?
 [A: C,12; H,1; N,14; O,16]

Answer [2]

Kevlar is a fire resistant material, which is also much stronger than nylon. The strength of Kevlar is one property which makes it suitable for the replacement of steel cord in tyres. Kevlar belongs to a family of polyamides called aramids.



- (d) Suggest three other useful properties of Kevlar which arise from its structure.

.....

 [3]

Spiders produce a special type of silk to support their webs. Scientists have discovered that this silk is, weight for weight, stronger than Kevlar.

Scientists have isolated the gene responsible for making this silk. They inserted this gene into *E. coli* bacteria. The bacteria then produced the silk.

- (e) Outline the stages in the genetic engineering technique that allowed scientists to transfer the gene and so use *E. coli* bacteria as an 'artificial spider'.

.....

 [4]

[Total : 18]